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DOMESTIC PREPAREDNESS PROGRAM: TESTING OF APD2000 CHEMICAL WARFARE AGENT DETECTOR AGAINST CHEMICAL WARFARE AGENTS SUMMARY REPORT

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This report characterizes the chemical warfare (CW) agent detection potential of the commercially available APD2000 Chemical Agent Detector. These detectors were tested against HD, GB, and GA vapors at various conditions. The report is intended to provide the emergency responders concerned with CW agent detection an overview of the detection capabilities of these detectors.

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PREFACE

The work described herein was authorized under the Expert Assistance (Equipment Test) Program for the U.S. Army Soldier and Biological Chemical Command (SBCCOM) Program Director for Domestic Preparedness. This work was started in May 1999 and completed in July 1999.

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1. INTRODUCTION

The Department of Defense (DOD) formed the Domestic Preparedness (DP) Program in 1996 in response to Public Law 104-201. One of the objectives is to enhance federal, state and local capabilities to respond to Nuclear, Biological and Chemical (NBC) terrorism incidents. Emergency responders who encounter a contaminated or potentially contaminated area must survey the area for the presence of toxic or explosive vapors. Presently, the vapor detectors commonly used are not designed to detect and identify chemical warfare (CW) agents. Little data are available concerning the ability of these commonly used, commercially available detection devices to detect CW agents. Under the Domestic Preparedness (DP) Expert Assistance (Test Equipment) Program, the U.S. Army Soldier and Biological Chemical Command (SBCCOM) established a program to address this need. The Design Evaluation Laboratory (DEL) at Aberdeen Proving Ground, Edgewood, Maryland, performed the detector testing. DEL is tasked with providing the necessary information to aid authorities in the selection of detection equipment applicable to their needs.

Several detectors were evaluated and reported during Phase 1 testing in 1998. Phase 2 testing in 1999 continues the evaluation of detectors, including the MIRAN SapphIRe Portable Ambient Air Analyzer, MSA tubes, the M90-D1-C Chemical Warfare Agent Detector, and the APD2000 Detector.

2. OBJECTIVE

The objective of this test is to assess the capability and general characteristics of the APD2000 Detector to detect chemical warfare agent vapors. This report is one of several reports on the Phase 2 evaluations of detectors conducted during 1999. The intent is to provide the emergency responders concerned with CW agent detection an overview of the detection capabilities of the detectors.

3. SCOPE

This evaluation attempts to characterize the CW agent vapor detection capability of the APD2000 detector. The agents used included Tabun (GA), Sarin (GB), and Mustard (HD). These were considered representative CW agents because they are believed to be the most likely threats. Test procedures followed those described in the Phase 1 Test Report[1]. The test concept was as follows:

a. For each selected CW agent, determine the minimum concentration levels (Minimum Detectable Level, MDL) where repeatable detection readings are achieved. The military Joint Services Operational Requirements (JSOR) for point sampling detectors served as a guide for detection sensitivity objectives.

b. Investigate the humidity and temperature effects on detector response.

c. Observe the effects of potential interfering vapors upon detector performance both in the field and in the laboratory.

4. EQUIPMENT AND TEST PROCEDURES

4.1 DETECTOR DESCRIPTION

Environmental Technologies Group, Inc. (ETG) manufactures the APD2000 detectors. The detector is marketed as a lightweight (approximately 6 pounds, including the batteries), handheld, portable detector designed for surveying the environment to identify specific CW agents and irritants. It contains a 10-millicurie Nickel 63 radioactive source. The detector can be operated in CW or irritant mode. For this evaluation, only the CW agent mode was considered. The APD2000 detects nerve and blister agents simultaneously in its CW mode. It also has data logging features to record monitoring events. The APD2000 employs ion mobility spectrometry (IMS) detection techniques. Sample air passes through the heated membrane and then is drawn into the cell assembly. The molecules are ionized by the radiation source. The resulting ions are swept down the drift tube where they become separated according to their mass and mobility toward the collector electrode. An electronic signature is produced for each ion, based on the time required to reach the collector electrode. The APD2000 will sound an alarm if the sample signal "matches" the required signature criteria.

In addition to the audible alarm, the detector also has a visible display that shows "reference level" readings and the "identity" of the substance detected. The reference level is a number between zero and 100 for the " specific CW agent" or the "class of CW agent" that caused the detector to alarm. Larger numbers indicate the presence of a higher concentration of vapor is suspected. The numeric values (26-50, 51-75, and 76 -100) are relative indications for low, medium, and high agent concentration responses, respectively, and will trigger the audio alarm. Response value below 25 indicates there is a detection of the displayed substance at low concentration levels below the alarm set point. The audio alarm will not sound when below the threshold set point. The reference class for this detector response can be either "nerve" or "blister", with or without a specific agent (GA, GB, GD, VX, HD, HN or L) identified. This feature, despite occasional mislabels, distinguishes this detector from others tested thus far. The detector also contains a back-flush pump that reverses the sample flow path to protect the cell assembly from gross contamination. Back-flush mode is activated when the detector displays a "high (76-100)" concentration detection. The detector cannot detect when it is in this "back-flush" mode until its sensor has been sufficiently purged.

Power sources to operate the APD2000 include six standard or rechargeable C batteries, AC adapter, or 9-18 Volt DC supply. Six C-type batteries can sustain approximately seven hours of operation at ambient temperature. The APD2000 operating specifications give the operational temperature range from -22°F to 126°F (-30°C to +52°C) and the relative humidity range from zero to 95%. Battery life decreases sharply at lower temperatures. DC power supply was used through the evaluation to ensure that the detector performance would not be affected by battery condition.

The figure is a digital photograph of the APD2000 detector. Three detectors were purchased for this evaluation and randomly labeled A, B, and C. Detectors A and B were used during the evaluations, and C was reserved for a backup when necessary.

Figure. APD2000 Detector

4.2 CALIBRATION

Operating procedures were followed according to the Users' Manual[2]. No daily instrument calibration is required to place the APD2000 detector into operation. After the power button is pressed, the detector completes a self-test and goes into standby mode. This startup procedure takes approximately three minutes. The detection performance is verified daily using the confidence test sampler provided with the detectors by the manufacturer. In order to perform the confidence check the detector mode must be changed by pressing the mode button until READY TEST appears on the display. One end of the confidence test sampler contains the simulant for blister agent and is labeled as "H". The other end contains a simulant for nerve agent and is labeled "G". If the detector is working properly, an alarm will occur within seconds after exposure to each of these simulants. The mode button is then pressed until READY CW appears on the display and the detector is ready for use.

4.3 AGENT CHALLENGE

The agent challenges were conducted using the Multi-Purpose Chemical Agent Vapor Generation System[3] with Chemical Agent Standard Analytical Reference Material (CASARM) grade CW agents. The vapor generator permits preconditioning of a detector with humidity and temperature conditioned air before challenging it with similarly conditioned air containing the CW agent.

Agent testing followed successful detector start up. First, conditioned air at the desired temperature and humidity from the vapor generator system was sampled by the detector for approximately one minute to establish the stable background of the detector for the air at each condition. Agent challenge began when the solenoids of the vapor generation system were energized to switch the air streams from the conditioned air only to the similarly conditioned air containing the agent. Each detector was tested three times under each condition. The time that the detector was exposed to the agent vapor until it alarmed was recorded as the alarm time. The time for clear down after the agent challenge was also noted. This is the time required for the detector to stop alarming after the agent vapor flow ends.

The detectors were each tested with the agents GA, GB and HD at different concentration levels at ambient temperature and low (<5%) relative humidity in an attempt to determine the minimum detectable level (MDL) and response characteristics. Additionally, the detectors were tested at relative humidity conditions of 50% and 90%, as well as the temperature extremes of -30°C (GA and GB), 0°C for HD, and +50°C (GA, GB and HD) to observe temperature and humidity effects. The sensitivity effects of relative humidity and air temperature on the detector responses were observed during tests using agent concentrations that were slightly higher than the MDL. The tests were conducted within the operating range of the detectors. HD was only tested down to 0°C due to its physical property limitations. Although HD freezes at approximately +15°C, it has a volatility of 92 mg/ m^3 at 0°C that is considered potentially hazardous. It should be noted that 0°C is lower than the current JSOR that only requires HD detection down to +15°C.

4.4 AGENT VAPOR QUANTIFICATION

The generated agent vapor concentrations were analyzed independently and reported in mg/m^3. The vapor concentration was quantified by the manual sample collection methodology[4] using the Miniature Continuous Air Monitoring System (MINICAMS®) manufactured by O. I. Analytical, Inc., Birmingham, Alabama. The MINICAMS® is equipped with a flame photometric detector (FPD), and operated in phosphorus mode for the G agents and sulfur mode for HD. This system normally monitors air by collection through sample lines and subsequently adsorbing the CW agent onto the solid sorbent contained in a glass tube referred to as the pre-concentrator tube (PCT). The PCT is located after the MINICAMS® inlet. Here the concentrated sample is periodically heat desorbed into a gas chromatographic capillary column for subsequent separation, identification, and quantification.

For manual sample collection, the PCT was removed from the MINICAMS® during the sample cycle and connected to a measured suction source to draw the vapor sample from the agent generator. The PCT was then re-inserted into the MINICAMS® for analysis. This

"manual sample collection" procedure eliminates potential loss of sample through sampling lines and the inlet assembly in order to use the MINICAMS® as an analytical instrument. The calibration of the MINICAMS® was performed daily using the appropriate standards for the agent of interest.

4.5 FIELD INTERFERENCE TESTS

Upon completion of the agent sensitivity tests, the detectors were tested outdoors in the presence of common potential interferents such as the vapors from gasoline, diesel fuel, jet propulsion fuel (JP8), kerosene, AFFF liquid (Aqueous Film Forming Foam used for fire fighting), household chlorine bleach and insect repellent. Vapor from a 10% HTH slurry (a chlorinating decontaminant for CW agents), engine exhausts, burning fuels and other burning materials were also tested.

The field tests were conducted outdoors at M-Field of the Edgewood Area of Aberdeen Proving Ground in July 1999. The detectors were placed at various distances downwind of the open containers, truck engines or fires, for example, 1-3 meters for vapor fumes and 2-5 meters for smokes depending on wind direction and velocity at test time. The objective was to assess the ability of the detectors to withstand outdoor environments and to resist "false positive" alarm indications when exposed to the selected "potential interference" substances.

A confidence check was performed on each detector at the beginning of each testing day. Particulate nozzle filters were used during smoky exposures as suggested in the User's manual. Two APD2000 units were exposed to each interferent for three trials of one minute exposure per trial with approximately five minutes clear down time between trials. After the third trial, confidence sample checks were conducted. If the sensitivity deteriorated, the detectors were allowed more clear out time. Testing continued with the next challenge approximately 5 minutes after the detectors had cleared.

4.6 LABORATORY INTERFERENCE TESTS

These tests were designed to assess detector response to vapor from representative substances, and to show the CW agent detection capability of the detectors in the presence of the potential interference vapors from AFFF and diesel fuel. The interferents were chosen based on the likelihood of their presence during an emergency response by first responders.

The APD2000 detectors were tested against "1% concentrations" of gasoline, JP8, diesel fuel, household chlorine bleach, floor wax, AFFF, Spray 9 cleaner, Windex, antifreeze, toluene, vinegar, and 25 PPM ammonia to observe potential interference with the detection reaction process. If the detector false alarmed at 1%, it was tested against an "0.1% concentration" of each interferent. To prepare the interferent test gas mixture, dry (<5% RH) air at 20°C was saturated with interferent vapor by passing it through the interferent liquid in a bubbler or by sweeping it over the liquid contained in a tube. Thirty milliliters of this vapor saturated air was then diluted to three liters of the conditioned air to produce the "1% concentration" of interferent. In the same manner, a 0.1% concentration of interferent was produced using three milliliters of vapor saturated air diluted to three liters of generator air to further test the detector if the detector

false alarmed at the higher concentration. The 25 ppm ammonia was derived by proper dilution of the 1% NH_3 vapor from an analyzed compressed gas cylinder. The dilution levels were chosen to represent possible occurrences in CW protective shelters.

The CW agent detection capability of the detectors in the presence of the potential interference vapors from AFFF and diesel fuel was assessed. The test gas mixture was prepared by using air (20°C, <5% RH) that was saturated with either diesel fuel or AFFF. Three milliliters of the vapor saturated air was diluted to three liters with the (20°C, <5% RH) conditioned air containing a prescribed concentration of CW agent from the agent generator to produce the "0.1% concentration" of interference mixture. The two APD2000 detectors were tested three times with each agent/interferent mixture and the detection responses were recorded.

5. RESULTS AND DISCUSSION

5.1 MINIMUM DETECTABLE LEVEL

The minimum detectable level (MDL) for the APD2000 detectors (A and B) are shown in Table 1 for each agent at ambient temperatures and low relative humidity (<5% RH). The MDL was established by lowering the agent concentrations until there was no response from the detectors. The MDL values were selected based on the lowest CW agent concentration exposure to produce alarms consistently for three trials. The MDL concentrations are expressed in mg/m^3 and the equivalent parts per million (ppm) values are shown. The current military requirements for CW agent detection (Joint Service Operational Requirements [JSOR] for CW agent sensitivity for point detection alarms), the Army's established values for Immediate Danger to Life or Health (IDLH), and the Airborne Exposure Limit (AEL) are also listed as references to compare the detector's performance.

When compared to the JSOR and IDLH values, the MDLs of the APD2000 units for the CW agents tested are all approximately an order of magnitude lower. Lower MDL represents better detection sensitivity. These detectors are capable of responding consistently to very low concentrations of the CW agents tested as indicated by the similar results of detectors A and B. Army regulation AR 385-61 does not establish an IDLH for HD due to concerns over carcinogenicity. The APD2000 units would not detect at the AEL levels.

Table 1. Minimum Detectable Level (MDL) at Ambient Temperatures and Low RH

AGENT	Concentration in milligrams per cubic meter, mg/m^3, With parts per million values in parenthesis (ppm)				
	APD2000 A	APD2000 B	JSOR*	IDLH**	AEL***
HD	0.220 (0.033)	0.220 (0.033)	2.0 (0.300)	N/A	0.003 (0.0005)
GA	0.027 (0.004)	0.027 (0.004)	0.1 (0.015)	0.2 (0.03)	0.0001 (0.000015)
GB	0.021 (0.004)	0.037 (0.006)	0.1 (0.017)	0.2 (0.03)	0.0001 (0.000017)

* Joint Service Operational Requirements for point sampling detectors.
** Immediate Danger to Life or Health values from AR 385-61 to determine level of CW protection. Personnel must wear full ensemble with SCBA for operations or full face piece respirator for escape.
*** Airborne Exposure Limit values from AR 385-61 to determine masking requirements. Personnel can operate for up to 8 hours unmasked.

5.2 TEMPERATURE AND HUMIDITY EFFECTS

Table 2 lists the average responses of the APD2000 detectors at various test conditions. Tests were conducted at ambient temperatures and RH conditions of approximately 0, 50 and 90%. The detectors were also tested at temperature extremes of –30°C (0°C for HD) and +50°C.

The APD2000 detectors successfully demonstrated CW agent detection at various temperature and humidity conditions. Most of the alarm and clear down times occurred within 30 seconds of agent exposure. The minimum detectable levels were approximately an order of magnitude lower than the current JSOR and IDLH standards.

The "reference level" readings are also shown in Table 2. Larger numbers indicate the presence of higher concentration of vapor is suspected. The numeric values (26-50, 51-75, and 76 -100) are relative indications for low, medium, and high agent concentration responses, respectively. Values below 25 are below the alarm threshold. The reference class for this detector response is "nerve" or "blister", with or without a specific agent (GA, GB, GD, VX, HD, HN or L) identified. Unfortunately, the specific identification response of the detector did not always correspond to the actual challenge CW agent because of overlapping of ion mobility spectrometry peaks. The detector would alarm but the reference indication was incorrect. For example, the detectors alarmed and indicated Blister and Nerve VX as well as Nerve GA during the GA tests. GB evaluations sometimes indicated Nerve VX instead of Nerve GB. In addition, the HD tests showed a variety of indications including Blister L and Nerve VX, as well as the correct Blister H response.

In the cold temperature (-30°C only), the detectors had power and LCD display visibility problems. The detectors were difficult to start and the LCD display was extremely difficult to

read. In one case, unit A failed to power up in the cold temperature and unit C had to be used for that test.

Table 2. Alarm Responses at Various Temperatures and Relative Humidity Conditions

AGENT	Average Temperature °C	Relative Humidity %RH	Concentration mg/m³	APD2000 Detector A			APD2000 Detector B		
				Reference Units	Agent Class	Alarm Time Range (seconds)	Reference Units	Agent Class	Alarm Time Range (seconds)
HD	20	<5	0.22	45	Blst H	7-10	30	Blst L	19-21
HD	20	<5	1.49	65	Blst H	6-9	55	Blst	4-6
HD	20	<5	2.16	100	Blst H	4-7	65	Blst H	6-8
HD	20	<5	55	100	Blst H	3-6	100	Blst H	5-6
HD	20	50	2.20	100	Blst H	5	55	Blst	4-7
HD	20	>90	1.89	65	Blst H	4-10	55	Blst	5-6
HD	0	0	1.81	65	Blst H	7-52	65	Blst	5-7
HD	50	<5	1.68	100	Blst H	7-8	100	Blst H	5-8
GA	20	<5	0.027	32	Nerve VX	11-106	32	Nerve VX	54-94
GA	20	<5	0.100	55	Nerve/Blst H	8-39	60	Nerve GA	22-69
GA	20	<5	9.22	55	Blst H/GA	3-26	40	Blst H	4-12
GA	20	50	0.100	40	Nerve GA	23-92	35	Nerve GA	26-29
GA	20	>90	0.112	60	Nerve GA	18-41	60	Nerve GA	21-23
GA	-30	0	0.110	32	Nerve VX	10-14	30	Nerve GB	5-31
GA	50	<5	0.084	52	Nerve	10-16	45	Nerve GB	19-22
GB	20	<5	0.021	30	Nerve GB	28-46	Not Tested	Not Tested	Not Tested
GB	20	<5	0.037	Not Tested	Not Tested	Not Tested	30	Nerve GB	56-95
GB	20	<5	0.092	50	Nerve GB	15-31	40	Nerve GB	16-21
GB	20	<5	33	100	Nerve VX	5-6	100	Nerve GB/Nerve	3-7
GB	20	50	0.14	60	Nerve GB	16-20	50	Nerve GB	15-20
GB	20	>90	0.07	45	Nerve GB	16-19	35	Nerve GB	16-21
GB	-30	0	0.06	30*	GB	14-17	30	GB	15-25
GB	50	<5	0.08	45	Nerve GB	19-21	35	Nerve GB	17-23

- *Unit A replaced with APD2000 C for this test.
- Blst = blister agent

5.3 FIELD INTERFERENCE

The detector 'false alarm' results for the field test interferent exposures are presented in Table 3. False alarms indicate that the detector alarmed in the absence of CW agent. The ambient temperature and relative humidity levels during these tests were in the range of 26-36°C and 53-91% RH, with gentle wind. Detector A was replaced with Detector C during the field testing due to frequent VX false alarms.

The field test false alarm rate showed that both detectors false alarmed one out of three trials for the JP8 vapor and AFFF vapor. The displays showed VX and GD for detectors B and C, respectively, for JP8. For AFFF, the displays showed VX and GA for detectors B and C, respectively. The other field test interferents did not cause the detectors to alarm.

Post field test responses against HD and GA showed the APD2000 detectors to have no adverse residual effects from the field tests. The units alarmed for the agents with similar response levels after the field tests when evaluated against HD and GA at similar pre-field test conditions.

Table 3. Field Interference Testing Summary

Interferent	APD2000 Detectors B and C*, One minute interferent exposures		
	Alarms/Trials Unit B	Alarms/Trials Unit C	Display Reading B,C
Gasoline Exhaust, Idle	0/3	0/0*	None
Gasoline Exhaust, Revved	0/3	0/0*	None
Diesel Exhaust, Idle	0/3	0/3	None
Diesel Exhaust, Revved	0/3	0/3	None
Kerosene Vapor	0/3	0/3	None
Kerosene on Fire	0/3	0/3	None
JP8 Vapor	1/3	1/3	VX,GD
Burning JP8 Smoke	0/3	0/3	None
Burning Gasoline Smoke	0/3	0/3	None
Burning Diesel Smoke	0/3	0/3	None
AFFF Vapor	1/3	1/3	VX,GA
Insect Repellent	0/1	0/1	None
Diesel Vapor	0/3	0/3	None
Gasoline Vapor	0/3	0/3	None
HTH Vapor	0/3	0/3	None
Bleach Vapor	0/3	0/3	None
Burning Cardboard	0/3	0/3	None
Burning Cotton	0/3	0/3	None
Burning Wood Fire Smoke	0/3	0/3	None
Doused Wood Fire Smoke	0/3	0/3	None
Burning Rubber	0/3	0/3	None

*Detector A was unsuccessfully used during these trials and removed from field test for continuous electronic noise VX false alarms. Detector C replaced it for the remainder of the field tests.

5.4 LABORATORY INTERFERENCE TESTS

Table 4 presents the results of testing the detectors with conditioned air containing GA, GB, or HD in the presence of diesel fuel vapor or AFFF vapor. The detectors A and B were able to detect and identify the CW agents in the presence of these interferents.

Table 4. Average Results of Laboratory Interference Tests with Agents

Agent	Interferent	Concentration		Reference Level			
		mg/m^3	Ppm	APD2000 A		APD2000 B	
GA	0.1% AFFF	**0.07**	0.0104	Nerve GA	60	Nerve GA	50
GA	0.1% Diesel	**0.1**	0.0148	Nerve GA	60	Nerve GA	50
GB	0.1% AFFF	**0.07**	0.0120	Nerve GB	50	Nerve GB	45
GB	0.1% Diesel	**0.07**	0.0120	Nerve GB	45	Nerve GB	45
HD	0.1% AFFF	**1.7**	0.2570	Blister H	70	Blister H	55
HD	0.1% Diesel	**1.7**	0.2570	Blister H	55	Blister H	60

Laboratory evaluations to determine if other potential interferent compounds would cause the detector to false alarm are summarized in Table 5. If an alarm occurred at the 1% saturation level, the interferent was reduced to 0.1% saturation and tested again. These tests were conducted without using the CW agents. Detectors A and B both alarmed for 8 out of 12 substances tested at the 1% concentration level.

The false alarm rates were less frequent at the 0.1% concentration level. Those substances that did not cause false alarms at the 1% level were not further tested at the 0.1% level. Nevertheless, detector A false alarmed for 4 out of 9 tests, and detector B false alarmed for 2 out of 9 of the interferents tested at 0.1% concentration.

Table 5. Average Results of Laboratory Interference Tests without Agents

Interferent Only	Detector A Reference Levels		Detector B Reference Levels	
	1%	0.1%	1%	0.1%
AFFF	Nerve VX	No Alarm	Nerve VX	No Alarm
Antifreeze	Nerve VX	Nerve VX	Nerve VX	No Alarm
Bleach	Nerve GA	No Alarm	Nerve VX	No Alarm
Diesel	No Alarm	No Alarm	No Alarm	No Alarm
Floor Wax	Nerve VX	Nerve VX	Nerve VX	No Alarm
Gasoline	No Alarm	Not Tested	No Alarm	Not Tested
JP8	Nerve VX	No Alarm	Nerve VX	No Alarm
Spray 9	Nerve VX	Nerve GB	Nerve	Nerve GB
Toluene	No Alarm	Not Tested	No Alarm	Not Tested
Vinegar	Blister L	No Alarm	Blister L	No Alarm
Windex	Nerve VX	Nerve VX	Nerve	Nerve VX
Ammonia (25 ppm)	No Alarm	Not Tested	No Alarm	Not Tested

6. CONCLUSIONS

The APD2000 detectors have demonstrated CW agent vapor detection for HD, GA and GB. The minimum detectable levels for the CW agents tested are approximately an order of magnitude better than the current military JSOR sensitivity requirements for a point sampling alarm. The two detector units produced consistently similar responses at all conditions tested.

The ability to detect agent in the presence of an interfering vapor, when the vapor itself does not cause a false alarm, has been demonstrated.

Civilian first responders and HAZMAT personnel are using Immediate Danger to Life or Health (IDLH) values to determine levels of respiratory protection selection during consequence management of an incident. Army Regulation (AR) 385-61 gives IDLH and Airborne Exposure Limit (AEL) values for GB/GA, and an AEL value for HD. AR 385-61 does not establish an IDLH for HD due to concerns over carcinogenicity.

The APD2000 detectors demonstrated detection of G agents to their IDLH values at all temperature and humidity conditions tested, however are unable to detect to the AEL values for HD, GA or GB.

Several problems arose during the evaluations. Specifically, cold temperature (-30°C only) operation caused excessive power consumption and the inability to read the display. The use of c-type batteries did not provide sufficient operational power. The inability to read the display panel made it impossible to get the detector into proper operational mode. Thus, the DC power supply was used through the evaluation to ensure that the detector performance would not be affected by battery condition. In the cold temperature testing, the detectors could only be started with the computer connected.

The automatic backflush feature disabled detection capability when it occurred. In addition, during the CW agent sensitivity tests, several false alarms at the reference levels Nerve or Nerve VX were observed while awaiting agent testing. Throughout the evaluation, the units' alarms would incorrectly display the wrong agent or wrong class of agent detected.

During interferent tests, the detectors alarmed to Nerve VX and Blister L for most of the false alarms. These false alarms and the frequency of alarms that occurred during the laboratory testing of the potential interferents cause concern. Results indicate that, despite the low false alarm rate observed in the field interference tests, the units are subject to more frequent alarms to many potential interference vapors when challenged in the laboratory under a more controlled and persistent exposure at 1% concentrations.

Following the detector evaluations, the manufacturer performed troubleshooting of the problems encountered during the testing. This was allowed because the detector showed CW agent sensitivity. They have offered the following explanations and possible corrective solutions.*

- At the beginning of this evaluation, Unit B frequently false alarmed. The cause was determined to be bad power/communications cable and/or connector cap that created numerous random peaks. These problems disappeared when the power cable was removed and the unit was operated on batteries. After removing the auxiliary connector, a wire was found clamped under the connector. This was corrected and false alarms due to electric noise disappeared. The unit can now be operated using the power cable.

- Unit B showed communications problems with the optional personal computer link. Several times, the unit lost communication. It had to be re-set to correct this problem. Initially, Unit A did not have electronic false alarms. It showed such false alarms as testing progressed. During field testing at M-Field, Unit A false alarmed so much that it had to be removed from testing.

*Extracted from correspondence with Dr. G. Lozos of ETG via email to Kwok Ong dated 12 October 1999.

- It is believed that the false alarms occurred during the field tests because the detector's internal temperature reached 50 degrees C. The false alarms decreased enough to allow further testing when returned for lab tests (at 25 degrees C), but did not disappear completely. It is possible that the higher temperature aggravated this problem. APD2000 detectors at ETG were examined and it was found that a connection was not properly soldered. It is thought that this would contribute to electronic noise.

- Unit A would not start up at –30 degrees C. Examination of detectors at ETG that had the same problem revealed that the "watchdog" timer was resetting and thus not allowing the unit to start up. This problem was corrected by changing the software so that the timing was made compatible with the "watchdog" timer to allow for timing variations caused by different temperatures.

- High (5 to 8 mg/m^3) concentration GA either alarmed as only Blister or Blister and GA or only alarmed when the challenge was removed from the detector. Recommendation is to change the GA agent classifier to improve GA detection.

- The High Voltage (HV) appears to be out of its specified range. The manufacturing processes need to be updated to verify HV at the board level compares to the HV numbers output in the log data.

If the problems are correctable as indicated in the manufacturer's comments, the APD2000 offers features that would be useful for first responders' applications. The detectors provided consistent CW detection sensitivity and the additional visual display information at less than alarm level indications is a plus. However, the high false alarm rates (8 of 12 substances tested) observed in the laboratory interference tests are of a major concern. This indicates that, during an operation using the APD2000, "alarms" very likely could be false indications of a "detected threat".

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REPORT NO.	ECBC-TR-151
TITLE	DOMESTIC PREPAREDNESS PROGRAM: TESTING OF APD2000 CHEMICAL WARFARE AGENT DETECTOR AGAINST CHEMICAL WARFARE AGENTS, SUMMARY REPORT
AUTHORS	Kwok Y. Ong, Terri L. Longworth, and Jacob L. Barnhouse
DATE	April 2001
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